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Automatic Detection Of Conflicts At Signalized Intersections

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Background and purpose

The Swedish Conflict Technique [1] is a well-known way of assessing the safety of a particular road design. In recent years the application of automatic image analysis instead of human observers has been examined, e.g. in [2].

The scope of this work is to develop a method for automatic image analysis using a double input from RGB and thermal cameras to provide time stamps of potential conflicts and traffic counts. Subsequently, an in-depth analysis of the potential conflicts is performed manually.

Studies have shown that the construction of bike paths results in a higher number of accidents with cyclists in intersections and in particular in those controlled by traffic lights [3], [4]. Through the years different designs of bike paths in signalized intersections have been established in order to improve the safety of cyclists. However, there is no clear evidence of when the different bike path solutions should be used and whether the best bike path solution differs with varying traffic volumes. In this work the assessment of the safety of cyclists is based on the number of near-collisions between cyclists and left/right turning cars. To facilitate the detection of potential near-collisions, video analysis techniques have been applied in this work. Concretely, a comprehensive case study compares five different designs of bike paths in signalized intersections.

The method

Two situations are of special interest to detect:

1. The time gap between a car and a cyclist with crossing trajectories is small
2. One or both of the road users stops near the intersection point between their trajectories in order to avoid a potential collision between the two road users

A tool using multi-modal imagery for automatic detection of interactions, and thus potential conflicts, has been developed. The tool utilizes a combination of RGB and thermal imagery. Whereas the RGB camera is able to capture a higher level of detail of the road users, the thermal camera might detect road users which would be invisible to the RGB camera due to shadows or result in false positives, see Figure 1. A full utilization of the thermal camera requires a synchronization of the RGB and thermal recordings, which is solved in a post-processing step.

Figure 1 - Shadows complicates the detection of a cyclist in the RGB recordings, whereas the cyclist is easily distinguished from the background in the thermal recording.

The tool measures the post-encroachment time of cars and cyclists in the conflict area, which is manually defined for each intersection.

The detection of potential conflicts is split into the subtasks of detecting:

- Straight going cyclists (SGC)
- Right turning cars (RTC)
- Left turning cars (LTC)

The output of these subtasks is used for the detection of potential conflicts and the computation of the time gap between the car and the cyclist.

The detection of these subtasks is handled by module-based program logic that consists of two blocks; flow detectors (F) and edge detectors (E). The configuration of each subtask is seen from Figure 2-4 below.

The flow detectors compute the dense optical flow of the predefined areas by using the algorithm of [5].

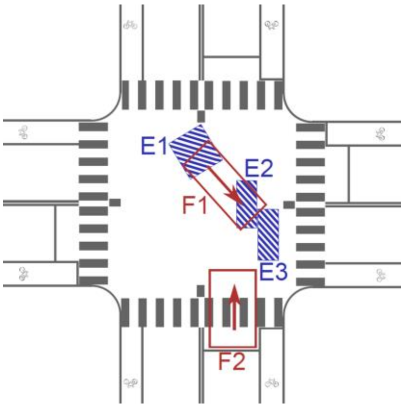

Figure 2 – Detection of left turning cars. Consists of three edge detectors and two flow detectors.

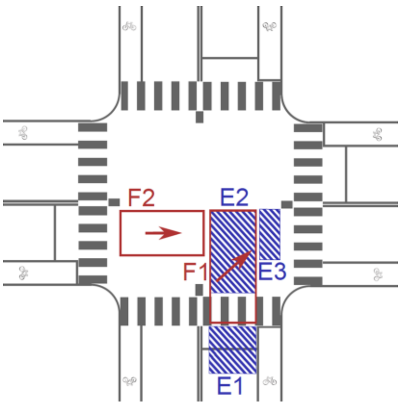

Figure 3 – Detection of right turning cars. Consists of three edge detectors and two flow detectors.

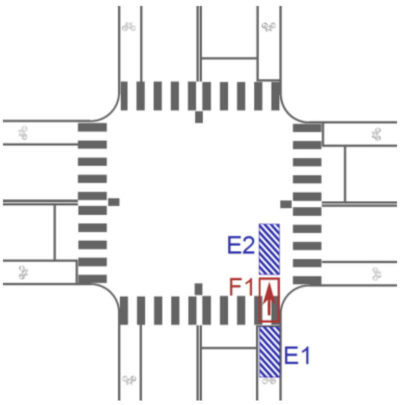

Figure 4 – Detection of straight going cyclists. Consists of two edge detectors and one flow detector.

The flow vectors of the algorithm are filtered such that only vectors within a specific angle range are counted. The flow detector is triggered whenever the number of vectors inside this range exceeds a predefined threshold. The average flow vector is of each region is illustrated by a red arrow in Figure 2-4.

Whereas the flow detectors determine if something is moving in a certain direction, the edge detectors determine if something is present within its region. The edge detectors rely on a background subtraction algorithm that uses the edge detection of [6]. Whenever the amount of edges becomes significant, the detector is triggered. If the amount of edges is not significant, the background is updated.

In order to detect a specific road user action, the blocks must be triggered in a pre-determined order that is specific to each detection subtask. The subtask of detecting left and right turning cars is distributed upon three edge detectors (E1, E2, E3) and two flow detectors (F1, F2). In order to detect a left or right turning car, the blocks E1, F1, E2, and E3 must be triggered in succession. If any activity in F2 is detected, the before mentioned blocks are deactivated for an interval of time to prevent false positives.

The subtask of detecting straight going cyclists is accomplished using two edge detectors (E1, E2) and one flow detector (F1). The detectors E1, F1, and E2 are activated in succession. If E2 is triggered, a straight going cyclist is detected. The logic of the three detection subtasks is listed in Figure 5.

	Left turning car	Right turning car	Straight going cyclist
E1	On	On	On
E2	On	On	On
E3	On	On	On
F1	On	On	-
F2	Off	Off	-

Figure 5 – Relationship between detection subtasks and their corresponding detector blocs. A detection subtask is triggered when the individual detector blocs (E1-E3, F1-F2) are triggered in the order shown above.

A potential conflict is detected if:

- A cyclist enters the conflict zone less than 2.5 seconds after a car has left the zone
- A cyclist leaves the conflict zone less than 1.0 seconds before a car enters the zone
- A car stops near the conflict area while a cyclist is present in the conflict area

In the detection subtasks of Figure 2 and 3, the conflict zone is the edge detector block E3. In the detection subtask of Figure 4, the conflict zone is E2. The specific layout of the masks is dependent of the properties of the intersection. The conflict zones of the car and cyclist detectors should overlap but not necessarily be identical.

Application of the method

The method described is expected to be capable of detecting the presence of road users on predetermined boundaries; however, it is still under development and needs to be validated. In the validation the results from the developed software will be compared to a manual detection of the potential conflicts. Then the method will be used in the comparison of the number of conflicts in intersections with different designs of the bike path across the intersection. At the workshop we will present preliminary results for these phases of the project.

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